

# An Online Resource for Flight Test Safety Planning

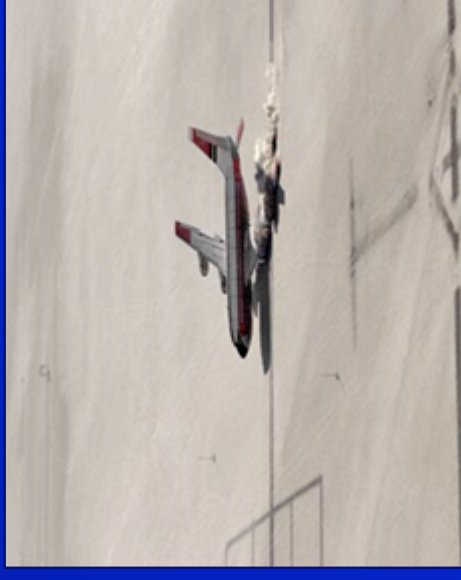
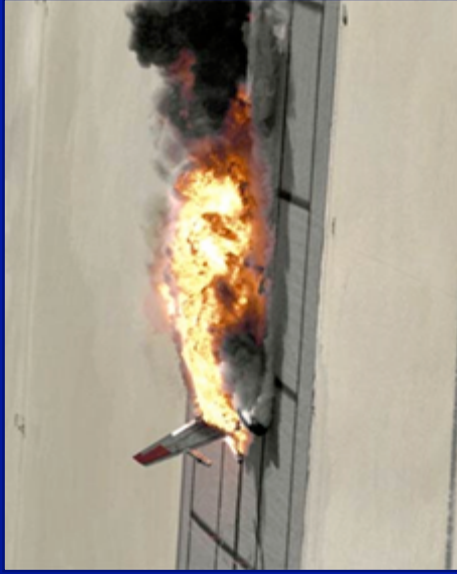
Greg Lewis  
*National Test Pilot School*





# Goal

- If the only goal is to be safe
  - Easy solution - don't fly
- The real goal is to get flight test data,
  - and to be as safe as possible while doing it
- Risk should be balanced against technical merit



NTPS



# Test Hazard Analyses

- Steps to balance risk with merit include:
  - Analyze the hazards
    - Identify causes and effects
  - Determine risk
  - Establish mitigating procedures
    - Consistent with objectives
- Results of THA's
  - Allow management to
    - Understand residual risks
    - Decide if risks are technically merited

## Test Hazard Analysis Worksheet

Test Title: Stall Characteristics	Hazard Category	Subjective Probability of Occurrence
		high      probable      uncertain      remote      improbable
<b>Aircraft/System:</b> NTPS Demo Sortie	catastrophic	
	critical	
	marginal	
	negligible	
<b>Hazard:</b> Aircraft departs controlled flight and impacts ground.		
<b>Cause:</b> Loss of control.		
<b>Effect:</b> Loss of aircraft and crew.		
<b>Minimizing Procedures:</b> <ol style="list-style-type: none"> <li>1. Minimum entry altitude - 2000 ft. AGL (B -35 4000 ft AGL, turpoprop/jet 5000 ft AGL)</li> <li>2. No aggravated input stalls. All stalls accomplished "ball -centered"</li> <li>3. No asymmetric power stalls in multiengine aircraft.</li> <li>4. Build up approach:               <ol style="list-style-type: none"> <li>i. forward cg before aft</li> <li>ii. power off before power on</li> <li>iii. wings level before turning</li> <li>iv. 1 kt/sec before accelerated</li> <li>v. terminate buildup if FAR bank angle limits are exceeded</li> </ol> </li> <li>5. Do not add power during recovery until above 1.2 Vs</li> <li>6. Departure/spin recovery discussed in preflight briefing.</li> </ol>		
<b>Emergency Procedures:</b> <ol style="list-style-type: none"> <li>1. If aircraft departs controlled flight, immediately retard power to idle and centralize controls.</li> <li>2. If aircraft enters spin, accomplish spin recovery procedure.</li> </ol>		
<b>Risk Level</b> (after minimizing procedures taken into account): High      Medium      Low      X		



# Online Database Background

- SETP/Flight Test Safety Committee
  - In 1997 tried to establish an online database of Lessons Learned
  - Effort aborted due to cost and web hosting issues
- NTPS
  - Developed and published THA's for all curriculum demo sorties
  - Those THA's made available to everyone online since 1998
- **In 2004, NASA-Dryden and the FAA forged a joint effort to**
  - To establish an online THA Database
  - Open website to anyone in the business
  - **NASA develop website and manage FAA data development**
- NASA-Dryden sub-contracted NTPS
  - To gather the data and populate the FAA THA data





# Data Gathering

- Strawman effort
  - NTPS THA's
    - Demonstration of classic Flight Test Techniques
    - Conservative limits
- Added inputs from the FAA
  - Aircraft Certification Offices in New York and Atlanta
- Next collected data from manufacturer's
  - Boeing Long Beach, Gulfstream, Lockheed, Bombardier, Cessna, Raytheon, and Boeing Seattle – data still coming in
  - All existing safety planning info, freely shared
- Most recent
  - Solicited inputs from Schweizer, Tiger, Boeing Rotary Systems, New Piper and Sikorsky





# NTPS Role

- Solicit and collect data
  - Primarily from manufacturer's doing civil certification
  - Those willing to share their flight test safety details
- We put the data into a common format
  - Not asking industry to change their safety planning process, just share what they have

Title: <input type="text" value="Stall Demonstration"/>		ManeuverId: <input type="text" value="Stall"/>	
Maneuver: <input type="text" value="Loss of Control"/>		Cause:	
Hazards:		Mitigation:	
1. Unpredicted aerodynamic response. 2. Stick Pusher fails to prevent aircraft from reaching aerodynamic stall. 3. Improper control inputs.		1. Do stall testing in a buildup approach: a. From least risk to highest risk i. forward cg, mid cg, aft cg ii. Power off before power on iii. Wings level before turning iv. 1 kt/sec before 3 kt/sec b. terminate buildup if FAR limits on bank angle are exceeded at any point of the buildup 2. Establish minimum altitude for test appropriate to the type of aircraft. Initially it should be sufficient to recover at least 10,000 ft agl. 3. Perform pre-flight checks of stall warning and stick pusher, as applicable. 4. Anti-spin chute must be installed, functional and armed. Perform pre-flight and pre-maneuver checks of chute as applicable. 5. Minimum crew onboard. 6. Emergency Egress system must be installed and armed. Perform pre-flight and pre-maneuver checks of egress system as applicable. 7. Crew to wear helmets and parachutes. 8. Surface winds must be less than 25 kts (bailout consideration). 9. No aggravated input stalls. All stalls will be ball centered. 10. No asymmetric nose stalls	
		Details:	
		As per AC 25-7A Section 6 "Stalls" Para 29 1) Trim hands off between 1.13 and 1.3 V <sub>sr1</sub> 2) 1 kt/sec decel wings level 3) 1 and 3 kt/sec turning 4) Power off and power on; 5) Power on = PLF at MLGW and 1.5 V <sub>sr1</sub> , flaps approach 6) Positive force to stall 7) Defined by nose down pitch not readily arrested; deterrent buffet; stick pusher; or stick at the aft stop (2 sec min)	



# NTPS Role (cont'd)

- “Mature” the data
  - To make the database useful to a user, there must be some integration of inputs
  - Searching for “stall” would have produced 66 separate records just from the early inputs
  - NTPS is consolidating mitigations by
    - Hazard (e.g. Loss of Control) and by
    - Maneuver (e.g. Stalls with Ice Shapes)
- This process requires
  - Common maneuver names
  - Common hazard names
  - Related to all appropriate FAR paragraphs





# Example Maturation

## Part 25 Stall Hazards





# Organizations

- Six different organizations submitted THA information regarding stall flight testing
  - Bombardier (12)
  - Cessna (1)
  - FAA (5)
  - Gulfstream (6)
  - NTPS (26)
  - Tiger (2)





# Hazard Titles

- 19 different titles including:
  - Stalls
  - Stall Speed
  - Stall Speed (Ice Shapes Installed)
  - Stalling Period
  - Stall Characteristics
  - Stall Characteristics with Delayed Turn (On Ice Shapes)
  - Wings level stall
  - Turning flight and accelerated turning stalls
  - Position Light System Installation
  - Demonstration of Misinstalled Thrust Reverser
  - Rudder Available Determination - A/C with 40% increased PCUs installed

# FAR Paragraphs

- Seven different Part 25 paragraphs originally had stall related hazards, but the matured data applies to:
  - 25.103, Stalling Speed
  - 25.201, Stall Demonstration
  - 25.203, Stall Characteristics
  - 25.207, Stall Warning





# Maneuver Name

- 14 different maneuver names
  - Stall speed determination
  - Stall characteristics determination
  - Stall
  - Stalls conducted with power on and off
  - Full stall (straight)
  - Full stall (turning)
  - Full stall (accelerated turning)
  - Straight stalls – contaminated leading edge
  - TCAS testing
  - Windshear Testing
  - Windmill airstart
  - APU flight test
  - Rudder available determination with 40%-increased PCUs installed
  - Simulated rejected takeoffs



# Identified Hazard

- Most varied field in submitted data
- The focus of maturing effort, along with minimizing procedures for the agreed-upon hazard identified
- As an example:
  - Original
    - “There is a risk of stall/departure from controlled flight when increasing angle-of-attack at low airspeeds.”
  - Became:
    - “Loss of control”
- For Part 25 stall tests, we ended up with just six hazards





# Matured Hazard Titles

- After submitted by NTPS and reviewed by the FAA and NASA, six hazards were identified with respect to Part 25 stall testing
  1. Loss of control
  2. Stall/spin chute fails to deploy
  3. Stall/spin chute fails to jettison when commanded
  4. Departing runway surface
    - (During ground test of stall spin chute)
  5. Recovery chute uncommanded deployment
  6. Loss of operating engine(s)



# Loss of Control Causes

- Many contributions of test safety planning did not include the “causes” – just the hazards and mitigations
- Of the ones submitted, the following were included in the matured THA’s
  1. Unpredicted aerodynamic response.
  2. Stick Pusher fails to prevent aircraft from reaching aerodynamic stall.
  3. Improper control inputs.





# Mitigations

- Literally hundreds of varied mitigations were matured into just twelve –
- The matured mitigations include:
  1. Do stall testing in a **buildup approach**:
    - a. from least risk to highest risk
      - i. forward cg, mid cg, aft cg
      - ii. Power off before power on
      - iii. Wings level before turning
      - iv. 1 kt/sec before 3 kt/sec
    - b. **terminate buildup** if FAR limits on bank angle are exceeded at any point of the buildup



# Mitigations (continued)

2. **Establish minimum altitudes** for:
  - a. entry,
  - b. recovery initiation,
  - c. recovery chute deployment and
  - d. manual bailout.
3. Perform **pre-flight checks** of stall warning and stick pusher, as applicable.
4. **Anti-spin chute** must be installed, functional and armed. Perform pre-flight and pre-maneuver checks of chute as applicable.
5. **Minimum crew** onboard.
6. **Emergency Egress system** must be installed and armed. Perform pre-flight and pre-maneuver checks of egress system as applicable.

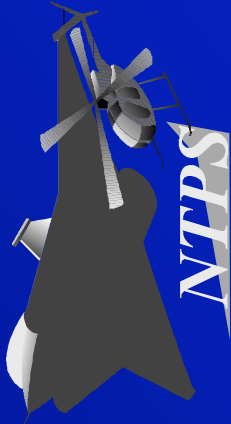


# Mitigations (continued)

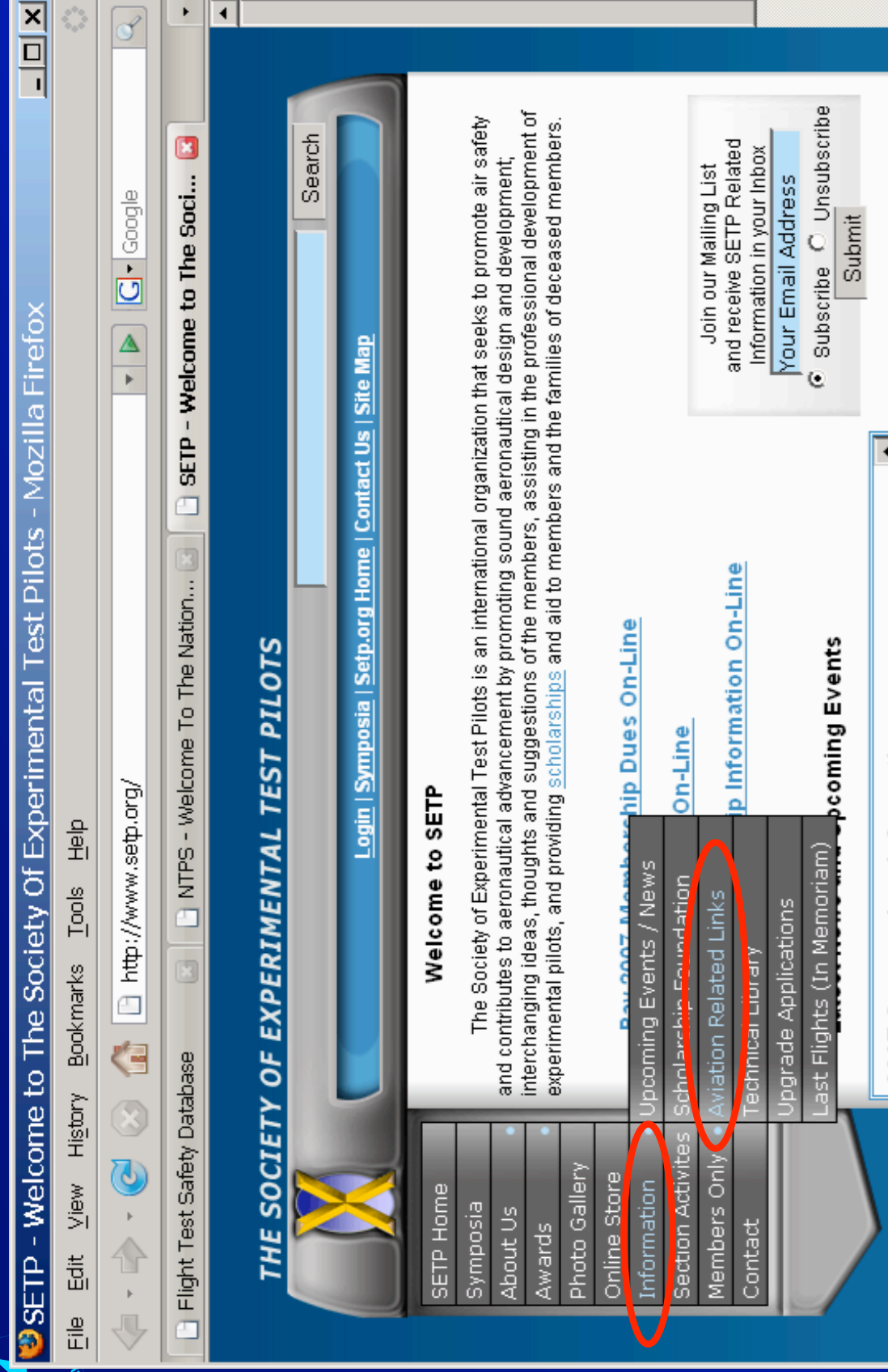
7. Crew to wear **helmets and parachutes**.
8. **Surface winds** must be less than xx kts (parachute dependent).
9. **No aggravated input stalls**. All stalls will be ball centered.
10. **No asymmetric power stalls**.
11. If departing controlled flight retard **throttles to idle and centralize controls**.
12. **Do not add power** during recovery until airspeed is increasing above 1.2 Vs.

# Database Now Open to the Public

<http://pbma.nasa.gov/ftsdb/>







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FLIGHT TEST SAFETY DATABASE



**Welcome**

For years the International Flight Test community has had a need for easy access to flight test maneuver descriptions, test hazards, and hazard mitigation techniques. This portal is a step in that direction, and builds on similar efforts by the Flight Test Safety Committee, the Society of Experimental Test Pilots, and the Society of Flight Test Engineers, and other professional organizations. Our objective is to identify and document hazards and mitigations associated with flight testing and provide a compilation of the flight test industry's corporate knowledge regarding flight test safety risk assessment. Where applicable, the database cross-references FAR guidance from Parts 23, 25 and other flight-test-related sections. It also discusses typical industry risk levels assigned to specific types of tests. All data has been reviewed by at least two persons with extensive Flight Test and/or Aviation Safety Experience. We hope you find this tool helpful, and solicit your feedback and contributions as we work to keep it up to date.

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10/26/2006





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# PBMA Process Based Mission Assurance Knowledge Management System



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## Reference Materials



- Acronyms
- Terminology
- Centers of Expertise
- Awareness and Safety Review Process
- FAR Parts
- Subject Matter Experts (SMEs)

## Hazard Search

Search Hazard Information from FAA Certification (FAR), Military Development, and Research data



Search Page

## FTSDB Key-Word Search



Keyword Search Page

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Favorites

## Announcements and Meetings

Announcements

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Submit Additional Flight Test Data

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- Event Calendar
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## Test Hazard Analysis Search

### Data Reference

	Number	Title
<input checked="" type="checkbox"/> FAA Certification (FAR):	(All) ▾	(All) ▾
<input type="checkbox"/> Military Development:	(All) ▾	(All) ▾
<input type="checkbox"/> Research:	(All) ▾	(All) ▾

### Record Fields

Discipline:	(All) ▾	Locates drop-down entry that best matches typed word
Maneuver:	(All) ▾	
Hazard:	(All) ▾	
Aircraft Type:	(All) ▾	
Aircraft Power Plant:	(All) ▾	
Uninhabited:	<input checked="" type="radio"/> (All) <input type="radio"/> Yes <input type="radio"/> No	

### Record Field Keyword

Finds keywords in selected fields to be searched. Results are limited to records satisfying criteria selected in record search above.

Select fields for your search: [Select all](#) | [Deselect all](#)

☐ Maneuver ☐ Hazard ☐ Reference Number ☐ Reference Title

Keyword(s):  [Clear Keywords](#)

[Submit](#) [Clear](#)



# FAR Reference Search

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Test Hazard Analysis Search

Data Reference

☒ FAA Certification (FAR):

☐ Military Development:

☐ Research:

Record Fields

Discipline:

Maneuver:

Hazard:

Aircraft Type:

Aircraft Power Plant:

Uninhabited:

Number

25.201

(All)

23.221

25.107

25.107(d)

25.109

25.147

25.149

25.149(b)

25.149(e)

25.177

25.201

25.203

25.207

25.253(a)3

25.831

25.854

25.855

25.857

25.858

25.1301

Title

Stall Demonstration

(All)

(All)

Record Field Keyword

Field documents are included. Fields that are excluded. Results are limited to records that are not deleted.

Locates drop-down e  
best matches typed





# Record Field Search

**Record Fields**

Discipline:

Maneuver:

Hazard:

Aircraft Type:

Aircraft Power Plant:

Uninhabited: ☒ (All) ☐ Yes ☐ No

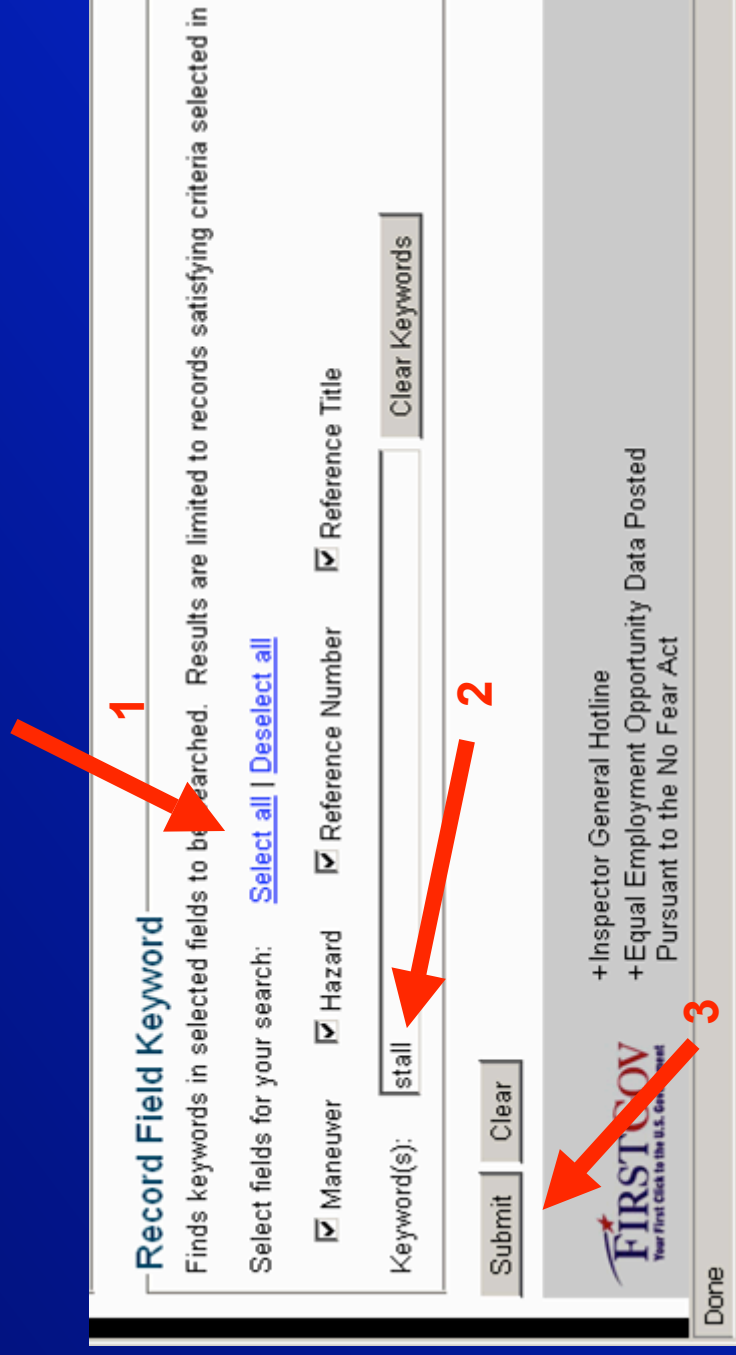
**Record Field Keyword**

Locates drop-down entry that best matches typed word

Find keywords in selected fields to be searched. Results are limited to records satisfying criteria selected in record search above.



# Keyword Search



**Record Field Keyword**  
Finds keywords in selected fields to be searched. Results are limited to records satisfying criteria selected in

Select fields for your search: [Select all](#) | [Deselect all](#)

☒ Maneuver ☒ Hazard ☒ Reference Number ☒ Reference Title

Keyword(s):

**FIRSTGov**  
Your First Click to the U.S. Government

+ Inspector General Hotline  
+ Equal Employment Opportunity Data Posted  
Pursuant to the No Fear Act

Done



# Results of FAR Reference Search

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## FLIGHT TEST SAFETY DATABASE

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### Search Results

FAA Reference No.: 25.201  
FAA Reference Title: Stall Demonstration

Check top box to select ALL records  
OR  
Check individual box(es) for desired records

Modify Search Criteria

Maneuver	Hazard	Discipline	Aircraft Type	Aircraft Power Plant	Uninhabited
<input type="checkbox"/> Recovery Chute Functional Test	Departing runway surface				No
<input checked="" type="checkbox"/> Stall	Loss of Operating Engine(s)				No
<input type="checkbox"/> Stall	Recovery chute uncommanded deployment				No
<input checked="" type="checkbox"/> Stall	Loss of Control				No
<input type="checkbox"/> Stall	Stall/spin chute fails to deploy when commanded				No
<input type="checkbox"/> Stall	Stall/spin chute fails to jettison				No

View Selected Records Sequentially | Combine Selected Records

Done

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## Combined Test Hazard Analysis

<b>Reference No.:</b> 25.201	<b>Reference Title:</b> Stall Demonstration	<b>Risk Level:</b> High
<b>Maneuver Title:</b> Stall		
<b>Maneuver Details:</b> As per AC 25-7A Section 6 "Stalls" Para 29		
<ol style="list-style-type: none"> <li>1) Trim hands off between 1.13 and 1.3 Vsr1</li> <li>2) 1 kt/sec decel wings level</li> <li>3) 1 and 3 kt/sec turning</li> <li>4) Power off and power on;</li> <li>5) Power on = PLF at MLGW and 1.5 Vsr1, flaps approach</li> <li>6) Stall defined by nose down pitch not readily arrested; deterrent buffet; stick pusher; or stick at the aft stop (2 sec min)</li> </ol>		
<b>Hazard(s):</b>		
Loss of Operating Engine(s)		
Loss of Control		

Note: The following Causes and Mitigations are listed in order of the hazards above.

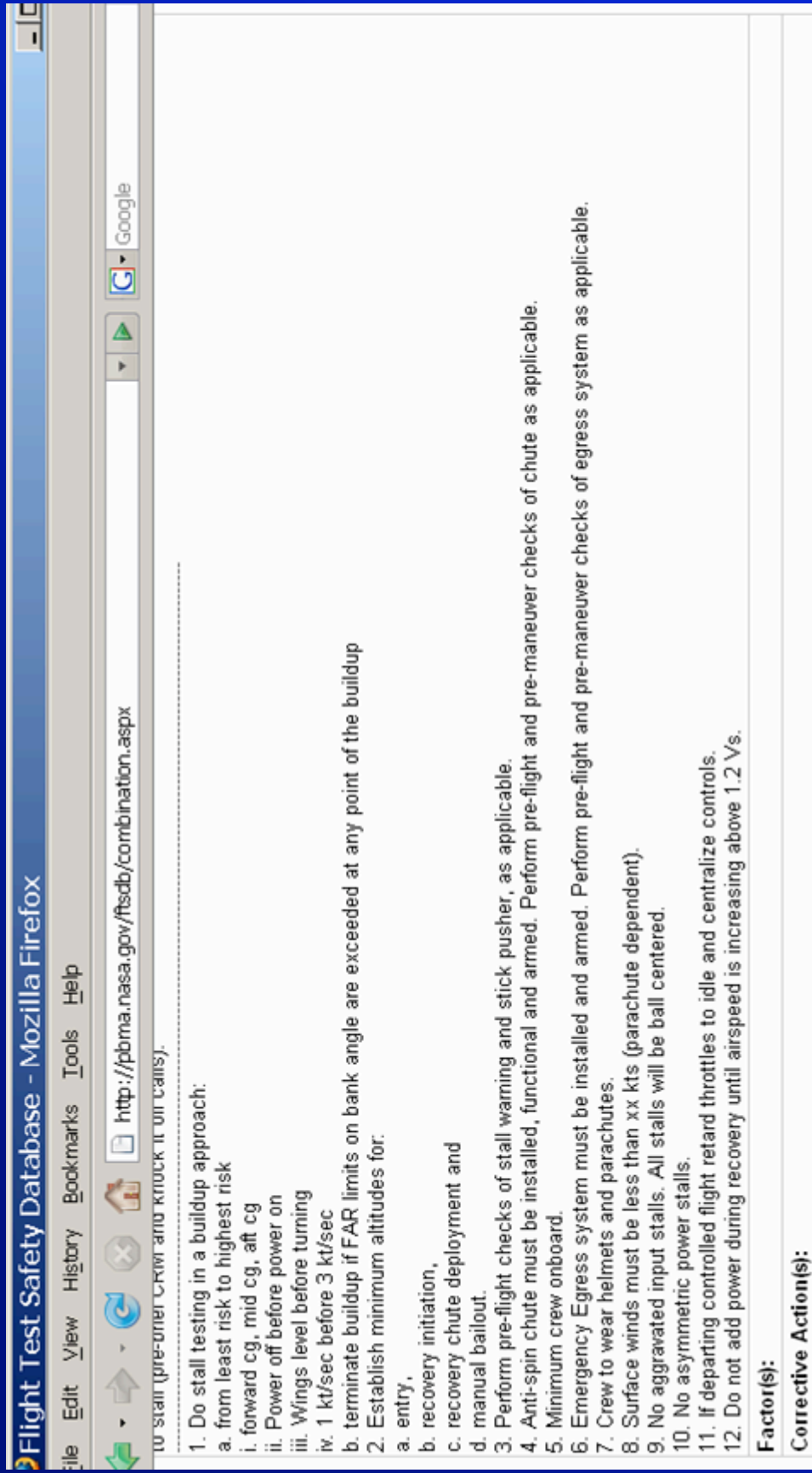
### Cause(s):

1. Inlet distortion leading to compressor stall
1. Unpredicted aerodynamic response.
2. Stick Pusher fails to prevent aircraft from reaching aerodynamic stall.
3. Improper control inputs.

### Mitigation(s):

1. Conduct approach to stall maneuvers at idle thrust before power on maneuvers.
2. At first onset of compressor distress, reduce AOA and reduce power to IDLE (if not already set to IDLE).
3. Shut down engine(s) if unable to prevent "locked-in" surge.
4. Conduct tests with APU running whenever possible.
5. Critical engineer parameters will be monitored real-time using telemetry, on-board GIFTS system or cockpit indications. Pre-brief CRM and engine knock-it-off calls.
6. Initial stall should be done with engine ignition and bleeds on.
7. All stalls should be done ball centered with symmetric power and if possible, sideslip should be monitored in real time and kept less than 5 degrees prior to stall (pre-brief CRM and knock it off calls).

Done





# In Conclusion

- Database status
  - Civil Part 25 THA’s “complete”
  - Civil Part 23/27/29/31 under construction
  - Military & research THA’s - TBD
- The matured THA database is **NOT** an auto-safety planning device
  - The matured hazards, causes and mitigations are necessarily generic
  - Your test will have unique problems and will require unique solutions
  - The THA database can be an excellent starting point
- Lessons learned should be shared
  - We don’t have enough time to learn every lesson firsthand

